

# WHAT IS CLAIMED IS:

1. A method of calibrating a reticle stage of a lithographic system, comprising:  
 directing a projection beam through a reticle such that said lithographic system generates an image of said reticle;  
 measuring a set of height offsets based on said reticle image;  
 decomposing said set of measured height offsets in accordance with a plurality of distortional factors;  
 determining reticle deformation attributes based on said distortional factors;  
 determining reticle stage deformation attributes based on said distortional factors and said reticle deformation attributes; and  
 calibrating said reticle stage based on said reticle stage deformation attributes.

2. The method of Claim 1, wherein said image generation includes scanning, within a slit area, an identifiable marker positioned on said reticle.

3. The method of Claim 1, wherein said image generation includes implementing sensors to detect vertical position focus levels.

4. The method of Claim 1, wherein said image generation includes exposing said reticle on a substrate.

5. The method of Claim 1, wherein said distortional factors are characterized by:

$$Z_{meas}(x, y_{sl}, y_{rs}) = z_0 + (FC_{lens} + FC_{xTIS})x^2 + (Ry_{sl} + ry_0 + Ry_r)x + (Rx_{sl} + rx_0 + W_r + W_{rs})y_{sl} + (W_r + W_{rs})y_{rs} + (C_{sl} + C_r)x \cdot y_{sl} + (C_{rs} + C_r)x \cdot y_{rs} + (Q_r + Q_{rs})y_{rs}^2 + Q_r^2 \cdot y_{sl} \cdot y_{rs} + (FC_{lens} + FC_{yTIS} + Q_r)y_{sl}^2$$

where

$Z_{meas}(x, y_{sl}, y_r)$  represents the height of said identifiable marker with said reticle stage at position  $y_{rs}$  and in said scan slit position  $x, y_{sl}$ .

$y_{rs}$  represents the position of said reticle stage in y;

$x, y_{sl}$  represents the position of a sensor operative with said identifiable marker;

$y_r$  represents the position on said reticle in y ( $y_r = y_{rs} + y_{sl}$ );

$z_0$  represents the height offset of said identifiable marker, a lens, said reticle, and said reticle stage;

$R_{y_{sl}}$  represents said scan slit tilt in x of said identifiable marker;

$R_{y_r}$  represents the tilt offset of said reticle;

$R_{y_{rs}}$  represents the tilt offset of said reticle and reticle stage;

$W_{sl}$  represents the wedge distortion in said scan slit;

$W_r$  represents the wedge distortion of said reticle;

$W_{rs}$  represents the wedge distortion of said reticle stage;

$Q_{sl}$  represents the quadratic contribution of said scan slit;

$Q_r$  represents the quadratic wedge distortion of said reticle;

$Q_{rs}$  represents the quadratic wedge distortion of said reticle stage;

$C_{sl}$  represents the corkscrew distortion of said scan slit;

$C_r$  represents the corkscrew distortion of said reticle; and

$C_{rs}$  represents the corkscrew distortion of said reticle stage.

6. The method of Claim 2, wherein said exposing includes maintaining said reticle fixed at a certain position while performing scanning measurements of said identifiable marker as said identifiable marker shifted to a plurality of predetermined positions.

7. The method of Claim 2, wherein said exposing includes maintaining said reticle fixed at a certain position while performing scanning measurements as an identifiable marker is shifted to a plurality of predetermined positions.

8. The method of Claim 2, where said identifiable marker includes sets of marks that are mirror images of each other and said exposing includes performing scanning measurements in two orientations.

9. The method of Claim 1, wherein said calibrating includes adjusting an actuation mechanism associated with said reticle stage to compensate for said reticle stage deformation attributes.

10. A system for calibrating a reticle stage of a lithographic system, comprising:  
an exposure apparatus configured to direct a projection beam of radiation through a reticle, supported by said reticle stage, in order to generate an image of said reticle;  
a measurement apparatus for measuring a set of height offsets based on said reticle image;

a processing mechanism configured to decompose said set of measured height offsets in accordance with a plurality of distortional factors, to determine reticle deformation attributes based on said distortional factors, and to determine reticle stage deformation attributes based on said distortional factors and said reticle deformation attributes; and

a reticle stage actuation mechanism to control position of said reticle stage, wherein said reticle stage actuation mechanism is adjusted in calibrating said reticle stage based on said reticle stage deformation attributes.

11. The system of Claim 10, wherein said exposure apparatus generates said reticle image by scanning, within a slit area, an identifiable marker positioned on said reticle.

12. The system of Claim 10, wherein exposure apparatus generates said reticle image by implementing sensors to detect vertical position focus levels.

13. The system of Claim 10, wherein exposure apparatus generates said reticle image by exposing said reticle on a substrate.

14. The system of Claim 10, wherein said distortional factors are characterized by:

$$Z_{meas}(x, y_{sl}, y_{rs}) = z_0 + (FC_{lens} + FC_{xTIS})x^2 + (Ry_{sl} + ry_0 + Ry_r)x + (Rx_{sl} + rx_0 + W_r + W_{rs})y_{sl} + (W_r + W_{rs})y_{rs} + (C_{sl} + C_r)x \cdot y_{sl} + (C_{rs} + C_r)x \cdot y_{rs} + (Q_r + Q_{rs})y_{rs}^2 + Q_r 2 \cdot y_{sl} \cdot y_{rs} + (FC_{lens} + FC_{yTIS} + Q_r)y_{sl}^2$$

where

$Z_{meas}(x, y_{sl}, y_r)$  represents the height of said identifiable marker with said reticle stage at position  $y_{rs}$  and in said scan slit position  $x, y_{sl}$ .

$y_{rs}$  represents the position of said reticle stage in y;

$x, y_{sl}$  represents the position of a sensor operative with said identifiable marker;

$y_r$  represents the position on said reticle in y ( $y_r = y_{rs} + y_{sl}$ );

$z_0$  represents the height offset of said identifiable marker, a lens, said reticle, and said reticle stage;

$R_{y_{sl}}$  represents said scan slit tilt in x of said identifiable marker;

$R_{y_r}$  represents the tilt offset of said reticle;

$R_{y_{rs}}$  represents the tilt offset of said reticle and reticle stage;

$W_{sl}$  represents the wedge distortion in said scan slit;

$W_r$  represents the wedge distortion of said reticle;

$W_{rs}$  represents the wedge distortion of said reticle stage;

$Q_{sl}$  represents the quadratic contribution of said scan slit;

$Q_r$  represents the quadratic wedge distortion of said reticle;

$Q_{rs}$  represents the quadratic wedge distortion of said reticle stage;

$C_{sl}$  represents the corkscrew distortion of said scan slit;

$C_r$  represents the corkscrew distortion of said reticle; and

$C_{rs}$  represents the corkscrew distortion of said reticle stage.

15. The system of Claim 11, wherein said exposing by said exposure apparatus includes maintaining said reticle fixed at a certain position while performing scanning measurements of said identifiable marker as said identifiable marker shifted to a plurality of predetermined positions.

16. The system of Claim 11, wherein said exposing by said exposure apparatus includes maintaining said reticle fixed at a certain position while performing scanning measurements as an identifiable marker is shifted to a plurality of predetermined positions.

17. The system of Claim 11, where said identifiable marker includes sets of marks that are mirror images of each other and said exposing includes performing scanning measurements in two orientations.